

# Memorandum

**To:** ISO Board of Governors  
**From:** Eric Hildebrandt, Director, Market Monitoring  
**Date:** January 27, 2011  
**Re:** **Market Monitoring Report**

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*This memorandum does not require Board action.*

## EXECUTIVE SUMMARY

This report provides comments and recommendations by the Department of Market Monitoring (DMM) on the regulation energy management proposal being presented to the ISO Board of Governors by Management at the February 3, 2011 meeting. The memo also provides an update on two market performance issues addressed in DMM's quarterly report for the fourth quarter of 2010.

- **Regulation energy management proposal.** The regulation energy management (REM) proposal will allow new energy-limited but fast-ramping storage technologies – such as batteries and flywheels – to be utilized for regulation services in the ISO system market. Over the next few years, the ISO expects limited amounts of these new storage technologies to be built and available for participation in the markets. However, these new technologies represent valuable potential system resources as increased reliance is placed on intermittent renewable resources. DMM believes the current proposal provides an adequate framework for integration of the relatively small quantity of REM capacity expected to participate in the regulation market initially, and the incremental rate at which additional capacity may be developed. This provides the ISO and potential developers of these resources with the opportunity to gain valuable experience operating these resources for regulation services in this initial phase. Key details of how the energy-limits of these technologies will be managed in the real-time market still need to be developed and refined as part of the implementation of this market enhancement. These include the extent to which these resources may be dispatched differently than conventional regulation resources and decision rules for re-charging these resources with energy from the real-time energy market. The ISO has indicated it will closely monitor the development and performance of regulation energy management resources and modify the regulation energy management requirements and design as appropriate.

This will allow the ISO and stakeholders to review and refine various market and operational elements as appropriate before the amount of REM capacity reaches significantly higher levels.

- **Real-time energy market performance.** In the fourth quarter of 2010, average prices in the 5-minute real-time energy market rose significantly above prices in the day-ahead and hour-ahead markets. Real-time prices were driven up by a significant increase in relatively short but extreme price spikes. Most of these high prices were attributable to relatively minor shortages of upward ramping capacity lasting no more than a few 5-minute intervals. These price spikes generally do not reflect an underlying shortage of total potential capacity and may be avoided by further modeling and dispatch improvements that increase the accuracy and flexibility of real-time dispatches. The ISO has been developing several such improvements that appear to have the potential to lower the frequency of such extreme price spikes. Implementation of several of these improvements has been delayed, but appears to be on track for implementation shortly before or after the implementation of convergence bidding on February 1, 2010. While convergence bidding may reduce the recent divergence of hour-ahead and real-time prices, DMM is recommending that the ISO continue to pursue modeling and operational enhancements as a more economically efficient means of reducing extreme price variations and divergences.
- **Multi-stage generating resources.** The ISO implemented functionality for multi-stage generating units on December 7, 2010. At this time, DMM has limited market and operating data upon which to assess the performance of this new market feature. A relatively limited number of generating units initially opted to participate as multi-stage generators. Several of these resources switched back to being operated as conventional generating units in the first month of this new market feature. More recently, however, numerous other generating units have opted to begin operating as multi-stage generating units, so that the overall number of units utilizing this new market enhancement has increased slightly since it was first implemented. Numerous refinements in the new software have been identified and are being initiated to address problems observed during this initial implementation period. DMM believes that a more meaningful assessment of this functionality can only be made after these refinements are fully implemented and unit owners gain more experience bidding and scheduling multi-stage generation units.

## REGULATION ENERGY MANAGEMENT

### *Background*

DMM recognizes the importance of facilitating integration of this type of non-traditional technologies into the market and the potential benefit those technologies can provide. The fast-ramping storage technologies the regulation energy management proposal is designed to promote – such as batteries and flywheels – represent particularly valuable potential system resources as increased reliance is placed on intermittent renewable resources.

Over the next few years, the ISO expects limited amounts of these new storage technologies to be built and available for participation in the markets. At this time, the potential revenues from participation in the ISO's regulation market do not appear to be a key driver of the overall economics of these new technologies. However, development of these storage technologies may reach significant levels over the longer term due to state policies to promote energy storage and renewable integration, and potential breakthroughs in technology costs.

It is important to note that some of the key operating characteristics of these new energy-limited storage resources are different than those of conventional generating resources around which the current ancillary services market has been designed and operated. On one hand, these resources are faster-ramping than conventional generators. However, these energy-limited resources will often need to be charged or discharged in the 5-minute real-time energy market in order to provide regulation in the same manner as conventional resources for a full hour. This will require development of new automated dispatch procedures or "smart algorithms" to take full advantage of their fast-ramping capabilities, while managing how these resources rely on the real-time market to be charged or discharge excess energy.

The relatively slow rate at which these new limited energy technologies are expected to be phased in over the next few years provides the ISO and potential developers of these resources with the opportunity to gain valuable experience operating these resources for regulation services during this initial phase. Based on this experience, the ISO can make any modifications that may be appropriate if the amount of this energy-limited storage capacity increases substantially.

### ***Regulation energy management proposal***

DMM has been very actively involved in the design and review of the regulation energy management proposal throughout the stakeholder process. Throughout this process, DMM has suggested numerous specific modifications and clarifications it feels would improve the proposal. DMM recommended several key modifications that have been incorporated in Management's final proposal. These include:

- **Settlement of imbalance energy.** Initially, the ISO proposed that regulation energy management resources would not be charged (or paid) for the amount of energy injected or extracted in the real-time energy market for regulation dispatches or the energy needed to maintain their state of charge. DMM noted that inefficiencies of limited energy resources typically range between 50 percent and 85 percent. The resulting 15 percent to 50 percent energy loss is the "fuel" that these resources use to provide the energy service and should therefore be charged for consuming that energy. Charging each REM resource for the net real-time energy costs incurred when charging and discharging will ensure that the true "operating cost" of alternative energy-storage technologies is factored into investment and market decisions. In addition, failure to recover these costs from regulation energy

management resources would result in uplift costs that would need to be charged to measured demand. The final proposal addresses this issue by settling each REM resource on the amount of energy injected/extracted during each interval.

- **Eligibility of conventional generating units for treatment as regulation energy management.** The initial proposal also allowed any resource the option of being treated as a regulation energy management resource. DMM questioned whether there was any potential rationale or benefit of allowing traditional thermal generating resources to choose to be treated as regulation energy management resources. This option seemed to conflict with the fundamental purpose of regulation energy management as a means of managing energy-limited resources differently so that they could provide regulation over an entire hour by being charged or discharged in the real-time energy market. As discussed in the following bullet, DMM also felt this provision could result in unintentional limitations being placed on the overall supply of regulation. The final proposal restricts the type of resources that can opt as regulation energy management to energy limited resources and does not allow traditional generators to participate as REM resources.
- **Limit on use of regulation energy management to meet regulation requirements.** The initial proposal included a 10 percent limit on the portion of regulation requirements that could be met by regulation energy management resources. This 10 percent limit was designed to enable operators to gain experience with regulation energy management resources, but limit the overall reliance placed on these resources. However, when combined with the provision allowing conventional generators to be treated as regulation energy management resources, DMM felt this 10 percent limit could have the unintended effect of restricting the overall supply of regulation resources. This could occur since traditional generators that opted to become regulation energy management capacity would only be allowed to provide up to 10 percent of regulation requirements, and would be removed from the pool of capacity available to meeting the remainder of the ISO's regulation requirements. DMM also felt the 10 percent limit was unwarranted at this time given that the ISO does not foresee the development of that level of regulation energy management resources over the next few years. The latest proposal eliminates the 10 percent limit, and includes a commitment by the ISO to monitor the development and performance of REM resources and modify the requirements and design as appropriate, based on this experience and the amount of regulation energy management resources that are actually developed.

### ***Further implementation details***

The need for management of regulation energy management resources by the ISO stems from the 15-minute energy requirement incorporated in the proposal. Resources meeting this requirement will only have enough stored energy to sustain their full regulation output for 15 minutes. In order to provide upward regulation in the same manner as conventional

resources for a full hour, these resources will often need to be charged from the real-time energy market. Similarly, to provide downward regulation in the same manner as conventional resources for a full hour, these resources will often need to discharge excess energy into the real-time energy market. In addition, these resources may be dispatched to provide more or less upward or downward regulation as conventional regulation resources in order to manage the level and timing of when these resources are charged with energy from the real-time market.

DMM's comments on the final draft proposal released in December 2010 centered on the details of the manner in which regulation energy management resources will be dispatched and managed by the ISO on a real-time basis. The final draft proposal provided a simple description and example of how the regulation dispatches and charging of regulation energy management resources with energy from the real-time market would be managed. Based on DMM's analysis of the example provided with the final draft proposal, DMM recommended that the ISO seek to develop more sophisticated algorithms or decision rules to determine when regulation energy management resources are dispatched for regulation and are charged from or supply energy to the real-time energy market.<sup>1</sup>

Depending on the specific details of these "smarter" dispatch procedures and initial operational experience, DMM also suggested that future refinements may be appropriate in the other aspects of the initial program design. These include possibly increasing the energy storage requirement per MW of regulation capacity being sold in the market (i.e., above the 15-minute requirement in the ISO's proposal) and modifying rules for when "no-pay" provisions in the tariff are applied to rescind payments for regulation services.<sup>2</sup>

In response to this analysis and recommendation, the ISO clarified that the example provided to stakeholders with the final draft proposal made simplifying assumptions of how regulation energy management resources would be dispatched and charged, and that development of the exact optimization algorithm to be used will be part of the implementation of regulation energy management and may change over time as the penetration of resources using REM increases or system conditions change.

DMM's understanding is that the ISO may manage regulation energy management resources by dispatching these resources for regulation differently than conventional regulation resources with the goal of optimizing the overall fleet of regulation resources. Also, the ISO has indicated it will develop additional details for determining the *real-time energy offset*, which is the amount of additional energy that will be dispatched (or reduced) in the real-time energy market to charge or discharge the regulation energy management resource in order to maintain its ability to provide regulation on a 5-second basis.

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<sup>1</sup> See *Comments on Draft Final Proposal for Regulation Energy Management (REM) Department of Market Monitoring*, January 6, 2011, <http://www.caiso.com/2afe/2afee17a2b670.pdf>.

<sup>2</sup> Ibid.

## *Conclusions*

DMM feels that the current proposal provides an adequate framework for integration of the relatively small quantity of REM capacity that is expected to participate in the regulation market initially, and the incremental rate at which additional capacity may be developed. This provides the ISO and potential developers of these resources with the opportunity to gain valuable experience operating these resources for regulation services in this initial phase. The ISO has indicated it will monitor the development and performance of regulation energy management resources and modify the requirements and design as appropriate. Thus, the ISO and stakeholders will have time to review and refine various market and operational elements as appropriate before the amount of regulation energy management capacity reaches significantly higher levels.

Ultimately, if a significant amount of regulation energy management capacity is developed and/or the ISO determines it would be beneficial to have a new market for fast-ramping resources to facilitate renewable integration, a new product or different payment mechanism may be developed. This would provide a way to more explicitly recognize the differences between regulation energy management resources and conventional regulation resources, and incorporate these in resources requirements, system and market operations, and market pricing.

## **REAL-TIME ENERGY MARKET PERFORMANCE**

### *Divergence of hour-ahead and real-time prices*

The consistency of prices across the ISO energy markets is a key measure of overall market efficiency. A high degree of price consistency – or price convergence – is an indication that resource commitment and dispatch decisions are being optimized across the markets within the ISO, as well as between the ISO and neighboring control areas. Also, as discussed in DMM’s previous quarterly reports, when net imports are decreased in the hour-ahead scheduling process at relatively low prices and additional incremental energy is then purchased in the 5-minute real-time market at higher prices, this can also create substantial uplifts that must be recovered from load-serving entities through the real-time imbalance energy offset charge.

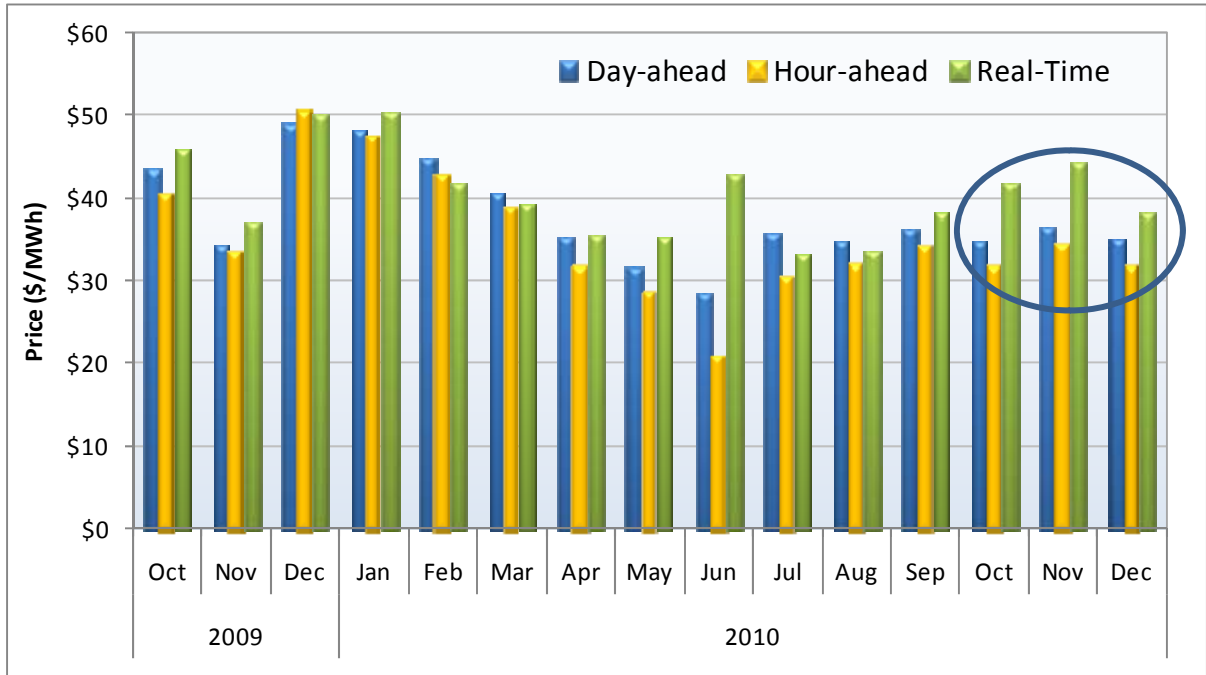
Since 2009, DMM has identified price divergence between the hour-ahead and 5-minute real-time markets as one of the most critical areas for further improvement in the new market software and processes. DMM’s quarterly reports for the third and fourth quarters of 2010 have focused heavily on a continuing trend of relatively low prices in the hour-ahead scheduling process for imports and exports, followed by higher average prices in the 5-minute real-time market.<sup>3</sup> In the fourth quarter of 2010, average prices in these markets

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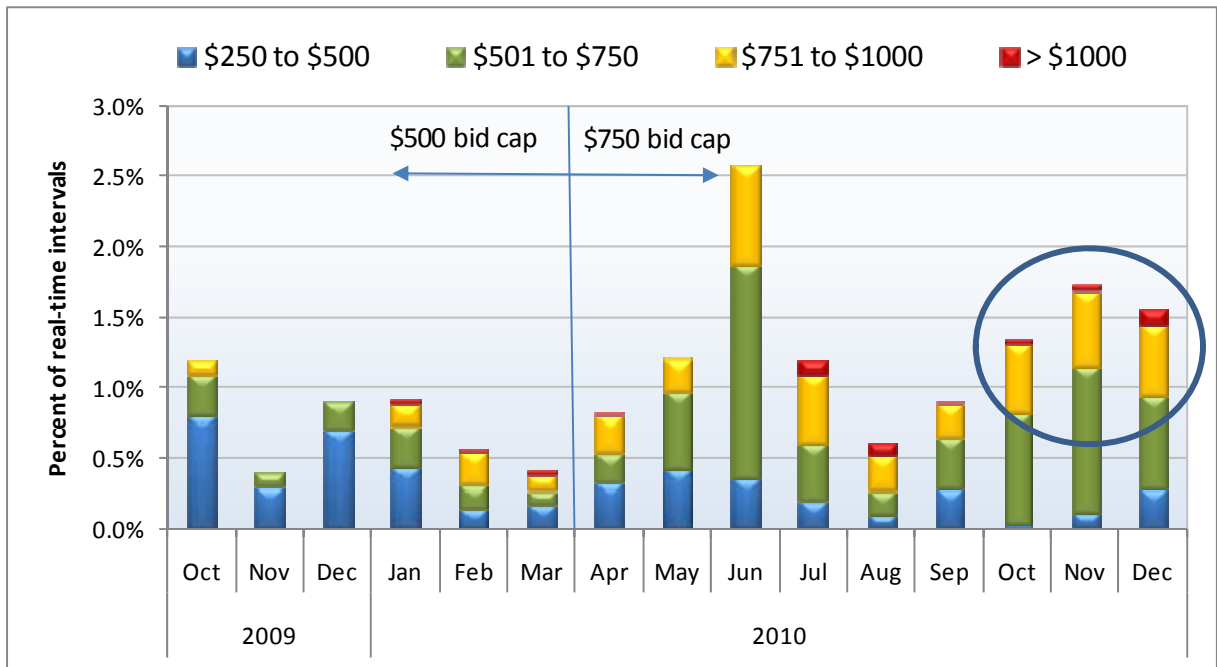
<sup>3</sup> *Quarterly Report on Market Issues and Performance*, Department of Market Monitoring, November 8, 2010, <http://www.caiso.com/2848/2848983817680.pdf>.

diverged even more significantly due to an increase in average prices in the 5-minute real-time energy market (see Figure 1).

**Figure 1. Monthly Average Prices (PG&E Area)**



**Figure 2. Frequency of Price Spikes (All LAP Areas)**



The increase in average real-time energy market prices in the fourth quarter of 2010 was driven by a significant increase in relatively extreme price spikes near or above the \$750/MWh bid cap. As summarized in Figure 2, these price spikes occurred less than 1.5 percent of hours. Without these extreme price spikes, average prices in the real-time market would have tracked very closely with the average hour-ahead prices shown in Figure 1. Average real-time prices would also have been slightly lower than average day-ahead prices if these extreme price spikes did not occur during these few intervals.

Most of the high real-time price spikes lasted no more than a few 5-minute intervals and were attributable to relatively minor short-term shortages of upward ramping capacity. For example, about three-fourths of price spikes due to shortages of upward ramping capacity persisted for only one to three consecutive 5-minute intervals (or five to 15 minutes).

One major factor that tends to create shortages of ramping capacity is the fundamental discrepancy between the 15-minute intervals used in the hour-ahead scheduling and 15-minute pre-dispatch, and the 5-minute dispatch intervals used in the real-time market. For example, schedules produced by these 15-minute processes may be optimal on a 15-minute basis, but not provide for sufficient ramping capabilities needed to balance loads and generation during the three 5-minute intervals within this 15-minute period.

The other major factor contributing to short-term shortages of ramping capacity is that actual conditions in the 5-minute market inevitably vary from projections of future conditions made in the hour-ahead scheduling process used to schedule imports and exports and the 15-minute pre-dispatch process used to commit short-start peaking resources. For example, specific factors observed to have caused or contributed to significant changes in imbalance energy needs between these scheduling processes and actual real-time conditions include the following:

- Differences between the load forecasts used in the hour-ahead and 15-minute pre-dispatch process and actual loads in the 5-minute real-time dispatch;
- Manual adjustments to these load forecasts, which may sometimes exacerbate price spikes by increasing load forecast differences or creating sudden changes in forecasted loads;
- Variable energy resources delivering more or less than forecast;
- Resources shutting down without sufficient notice;
- Contingency events, such as unit or transmission outages; and
- During some periods, high hydro run-off which decreases resource flexibility.

Thus, in most cases, these price spikes do not reflect an underlying shortage of total potential capacity and may be avoided by further modeling and dispatching improvements that increase the accuracy and flexibility of the hour-ahead and 15-minute pre-dispatch process.



### ***Initiatives to improve price convergence***

The ISO is implementing several key measures aimed at improving the consistency of hour-ahead and real-time prices and reducing the incidence of ramping capacity shortages in the 5-minute market. Implementation of several of these measures was planned in early 2010 and have been delayed, but many of these measures now appear close to final implementation. An update on these items are provided below:

- **Improving the forecast used in the hour-ahead and 15-minute pre-dispatch processes.** As previously noted, the ISO is continuing development of a new short-term forecasting tool designed to provide a more accurate and consistent forecast for both the hour-ahead scheduling process and the real-time market. Implementation of this new forecasting tool was anticipated in 2010, but is now scheduled for February 2011.
- **Providing improved guidance to the operators regarding manual load adjustment practices.** The ISO has indicated it is seeking to improve how and when to adjust or *bias* the load forecasts used in the hour-ahead and 5-minute real-time markets. As part of this effort, the ISO has provided additional training and guidance on use of load adjustments by market operators. The ISO is also developing a more systematic procedure that gives operators additional guidance to determine whether a load adjustment should be removed or continued. In addition, implementation of the new load forecasting tool should reduce the need for such manual adjustments.
- **Accounting for inter-tie ramping requirements in the hour-ahead scheduling process.** This enhancement will modify the hour-ahead scheduling process to account for ramping energy needed from the 5-minute real-time market to adjust to changes in the net import and export schedules each hour. This enhancement was implemented from December 3 until December 23, 2010, but was suspended in order to refine the rules for how this constraint impacts prices used to settle imports and exports when it is binding. The ISO anticipates this feature will be reactivated by February 2011.
- **Adding a new flexible ramping capacity constraint.** In early 2011, the ISO is seeking to implement a new *flexible ramping constraint* in the hour-ahead 15-minute pre-dispatch process. The flexible ramping constraint will explicitly require that the software optimization results include a pre-specified amount of additional ramping capacity (beyond levels needed to simply meet the energy forecast). This new constraint is designed to ensure that sufficient upward and downward ramping capability from 5-minute dispatchable resources is committed and available to balance loads and supply on a 5-minute basis, taking into account the potential variability in actual system conditions. When applied in the hour-ahead process, this constraint may cause the level of net imports to be better aligned with internal ramping energy needs. When applied in the 15-minute pre-dispatch process, this

constraint may trigger commitment of additional fast start units when additional upward ramping capacity is needed.

- **Unit start-up profiles.** Currently, when a generating unit is scheduled to start up, the market software does not account for the energy generated while the unit is ramping up to its minimum load level. On a system-wide basis, this can create several hundred megawatts of unscheduled energy during the early morning hours. Operators currently seek to compensate for this through manual load adjustments. The ISO is developing software enhancements to explicitly model the unscheduled energy expected from units starting up. The ISO expects to implement this enhancement in the second quarter of 2011.
- **Adaptive control enhancements.** The ISO has a mid-term initiative in 2011 to develop adaptive control enhancements that will explicitly predict and account for other various specific sources of uninstructed deviations. A simpler feature incorporated in the new market software to account for uninstructed deviations is currently disabled due to performance issues. Currently, operators must make adjustments, as appropriate, for uninstructed deviations through use of manual load biases.

DMM believes each of these initiatives represent important steps that will help reduce extreme price spikes due to short-term shortages of ramping capacity, which in turn will help promote convergence of average hour-ahead and real-time prices. DMM recommends that the ISO continue to seek to address the root causes of price divergence directly through these types of modeling and operational improvements even after the implementation of convergence bidding in February. Convergence bidding may reduce the recent divergence of hour-ahead and real-time prices. However, such modeling and operational enhancements are more economically efficient means of reducing extreme price variations and divergences.

## **MULTI-STAGE GENERATING UNITS**

The ISO implemented functionality for multi-stage generating units starting on December 7, 2010. At this time, DMM has limited market and operating data upon which to assess the performance of this new market feature. However, initial monitoring results indicate the following:

- Due to the uncertainties associated with this new market feature, only 11 generating units (representing 4,556 MW of total capacity) chose to operate as multi-stage generating units when this software was implemented. Several major combined cycle generating units switched back to being modeled as single configuration generation units within the first month of this new market feature. More recently, however, numerous other resource have opted to begin operating as multi-stage generating units, making the overall number of units utilizing this new market enhancement slightly higher than when it was first implemented.

- In some cases, it appears that performance of this new functionality from the perspective of generating unit owners may be improved as unit owners learn how to adjust bids for energy and the costs of starting up and transitioning between different unit configurations.
- Issues with the functionality have led to a notable increase in exceptional dispatches and blocked dispatch instructions for resources operating as multi-stage generating units. In most cases, these exceptional dispatches appear to be issued to “override” a dispatch from the market software in order to transition a unit to a new configuration or to keep the unit in its current configuration.
- Bid cost recovery payments appear to have increased somewhat for resources operating as multi-stage generating units. Final settlement data for these payments are not available at this time.
- Numerous refinements in the new software have been identified and initiated to address issues observed during this initial implementation period. The number of new software issues that have been identified appears to be dropping significantly.

As the ISO refines this new software functionality and participants gain more experience bidding and scheduling as multi-stage generating units, DMM notes that performance of this new market feature could improve. Over the longer run, there are several measures that will provide an indication as to how well this market feature is working:

- The frequency of exceptional dispatches and blocked dispatch instructions issued for multi-stage generating resources. To the extent the market dispatch improves as a result of this functionality, we would expect to see less frequent need for manual intervention to control these units.
- The frequency with which generation owners utilize the ISO’s outage management system (SLIC) to manage start-up, shut-down, and configuration changes by entering temporary adjustments to their unit operating characteristics. The need for such adjustments should be decreased for multi-stage generation units.
- A decrease in self-scheduling would provide an indicator that this feature is committing, de-committing, and dispatching multi-stage generating resources in a fashion consistent with what the resource schedulers believe is profitable, efficient, and consistent with their units’ operational capabilities and requirements.
- Bid-cost recovery payments made to multi-stage generating resources. Higher bid-cost recovery payments to multi-stage generating resources after implementation could indicate that resources were subject to uneconomic commitment or dispatch more than before implementation of this functionality.

- Feedback from the resource schedulers that they have observed commitment and dispatch among the resource configurations is profitable, efficient, and consistent with their unit's operational capabilities and requirements. One of the key forms of this type of feedback may be the number of units that eventually choose to operate as multi-stage generating units.

The ISO has committed to monitoring the impacts and effectiveness of the multi-stage generating units. DMM will also seek to provide an assessment of this new market feature in future market reports.